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Use of a T-flex toric intraocular lens to correct clinically significant astigmatism

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ABSTRACT

Purpose: To investigate the stability and effectiveness of T-flex toric intraocular lenses (IOLs) for the correction of regular corneal astigmatism during cataract surgery.

Methods: From October 2009 to January 2014 we enrolled patients receiving phacoemulsification and T-flex toric IOL implantation in the capsular bag at the Far Eastern Memorial Hospital. The uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), corneal astigmatism, refractive astigmatism, and the degree to which the IOL axis deviated from the demanded axis were recorded both before the operation and 6 months postoperatively.

Results: We enrolled 24 eyes of 24 consecutive patients in this study. The mean spherical power of the implanted toric IOLs was 17.13 ± 4.21 D (range 6.0–24.0 D) and the mean cylindrical power of the IOLs was 3.0 ± 0.86 D (range 2.0–5.0 D). At the 6-month follow up examination, the refractive astigmatism had improved from 3.21 ± 1.50 D to 0.77 ± 0.47 D ($p < 0.001$) and the spherical equivalence had improved from 4.47 ± 5.43 D to 0.63 ± 0.49 D ($p = 0.007$). The CDVA improved from 0.81 ± 0.45 logMAR to 0.09 ± 0.11 logMAR ($p < 0.001$). The mean improvement from the preoperative CDVA to the postoperative UDVA was 5.3 lines on the Snellen chart. Ninety-two percent of our patients achieved a postoperative UDVA ≥20/40 and 67% achieved a postoperative UDVA ≥20/25.

Conclusion: The T-flex toric IOL can effectively reduce visually significant corneal astigmatism and improve uncorrected distance visual acuity during cataract surgery.

1. Introduction

With advanced medical techniques, refractive problems can now be corrected during cataract surgery. After a cataract operation, patients now expect optimum visual outcomes and reduced dependence on spectacles. Approximately 15–29% of patients with cataracts have >1.5 D of corneal astigmatism.[1,2] Corneal astigmatism can be a significant factor influencing postoperative vision. Patients can try eye-glasses, rigid contact lenses, or excimer laser treatment to correct an astigmatism either preoperatively or postoperatively. Surgeons who treat astigmatism in patients with cataracts tend to use limbal relaxing incisions (LRI).[3–11] However, there are some potential risks to LRIs that should be considered, such as the over- or undercorrection of astigmatism and corneal perforation.[9] They are relatively unpredictable and imprecise, especially when correcting higher astigmatisms.[11] LRIs also depend on variable healing responses and the skill of the surgeon.[11] In addition, the amount of cylinder that can be corrected is limited.[3,10–13]

The toric intraocular lens (IOL) is another choice for the correction of corneal astigmatism. A number of studies have documented the efficacy of the toric IOL.[14–18] Sun et al[19] compared the effects of the toric IOL with LRI in correcting astigmatism during cataract surgery. They found a postoperative residual astigmatism <0.75 D in 55.4% of patients receiving the toric IOL, but in only 21.5% of the patients undergoing LRI. The use of toric IOLs to reduce

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visually significant refractometric astigmatism is a more predictable and stable method than the corneal approach.

We investigated the astigmatic correction and rotational stability of a Rayner T-flex injectable one-piece hydrophilic acrylic toric IOL in a series of patients with a regular keratometric astigmatism of ≥1.50 D.

2. Materials and methods

This research was carried out in accordance with the Declaration of Helsinki and after obtaining approval from the Institutional Review Board of the Far Eastern Memorial Hospital, Taipei, Taiwan. We collected data from patients who underwent uneventful torsional phacoemulsification (Alcon Lab, San Diego, CA, USA) in a 2.2 mm suture-less temporal corneal wound from October 2009 to January 2014. All the operations were performed by J.K. Wang, S.W. Chang, and E.L.C. Mai at the Far Eastern Memorial Hospital. The patients had visually significant age-related cataracts and a regular keratometric astigmatism of ≥1.50 D. Patients with uncontrolled glaucoma, pre-existing macular pathology or optic neuropathy, clinically unstable diabetic retinopathy, irregular keratometric astigmatism, poor compliance to follow up, or previous ocular surgery were excluded.

2.1. Preoperative assessment

Corrected distance visual acuity (CDVA) was measured using a Snellen chart. Refraction and keratometry were obtained using an automated refractometer (KR-8900, Topcon, Tokyo, Japan). The axial length, keratometry, and anterior chamber depth were measured with the IOLMaster Biometry system (Carl Zeiss Meditec AG, Jena, Germany). Corneal topography was performed to exclude irregular corneal astigmatism (Pentacam, Oculus, Berlin, Germany).

2.2. Calculation and implantation of intraocular lens

The IOLMaster biometric data, including axial length, keratometry, and anterior chamber depth, were input online into the Rayner T-flex IOL Calculator (https://www.toriciol.rayner.com/) to calculate the IOL spherical and astigmatic power, along with the optimum IOL axis position. The T-flex one-piece hydrophilic acrylic copolymer toric IOL (Rayner, Hove, East Sussex, UK) has an *A*-constant of 118.0 with a toric anterior surface and a posterior spherical surface.

Under topical anesthesia (proparacaine 0.5%; Alcaine, Alcon, Rijksweg 14, 2870 Puurs, Belgium), reference marks were made along the suggested axis of the IOL (the steep axis of astigmatism) at the peripheral cornea near the limbus with a 27-gauge sterile needle. The procedure was carried out at the slit lamp with the patient sitting upright to avoid the effects of cyclorotation in the supine position during the operation. After the cataract had been removed, the capsular bag was filled with viscoelastic materials. The T-flex IOL was injected into the capsular bag by a single-use soft-tipped IOL injector. After thorough removal of the viscoelastic material at the front and back sides of the IOL, corneal reference marks were used to align the IOL axis.

2.3. Postoperative assessment

The uncorrected distance visual acuity (UDVA), CDVA, refractive sphere, corneal astigmatism, refractive astigmatism, and spherical equivalent were recorded 6 months after the operation. The degrees of IOL axis deviation from the demanded axis were measured using slit lamp retroillumination images as described previously.[20,21] Preoperative and postoperative numerical data were compared using the paired *t* test.

3. Results

Twenty-four eyes of 24 consecutive patients were enrolled in this study. The mean age of the patients was 67.3 ± 12 years (range 53–88 years). The surgeries were performed in 16 right eyes and eight left eyes. The mean spherical power of the implanted toric IOLs was 17.13 ± 4.21 D (range 6.0–24.0 D) and the mean cylindrical power was 3.0 ± 0.86 D (range 2.0–5.0 D). Table 1 shows a significant improvement in the CDVA and a significant decrease in the refractive astigmatism, refractive sphere, and spherical equivalent 6 months after the operation ($p < 0.05$). There was no significant change in corneal astigmatism after the surgery ($p = 0.73$). The mean increase in the CDVA after toric IOL implantation was six Snellen lines. The mean improvement from the preoperative CDVA to the postoperative UDVA was 5.3 lines. A postoperative refractive astigmatism <1.50 D was found in 96% of eyes and a postoperative refractive astigmatism <1.0 D was noted in 70% of eyes. The UDVA was ≥20/40 (0.3 log MAR) in 92% of the eyes and ≥20/25 (0.2 log MAR) in 67% of the eyes (Fig. 1). The CDVA was ≥20/40 in 96% of the eyes and ≥20/25 in 75% of the eyes (Fig. 1). Fig. 2 shows that all the patients improved from preoperative corneal astigmatism to postoperative refractive astigmatism.

No patient had significant intra- or postoperative complications. The mean deviated degree from the intended axis was <5° in all patients after 6 months of follow up. The degree of IOL rotation was stable 1 day, 1 week, 1 month, 3 months, and 6 months postoperatively.

4. Discussion

The correction of astigmatism during cataract surgery facilitates postoperative visual improvements; these corrections can include the placement of the incision on the steep axis of the cornea, LRI, and toric IOL implantation.[22] Previous studies have compared the performance of the toric IOL and LRI in correcting corneal astigmatism.[23,24] The postoperative refractive astigmatism was comparable between groups of patients with pre-existing astigmatism within 1.5 D treated with either the toric IOL or LRI. However, the toric IOL achieved better results than LRI owing to the significantly lower refractive astigmatism found after implantation in patients with a pre-existing astigmatism of >1.5 D.[22] This is because LRI is relatively unpredictable and imprecise, especially in correcting higher astigmatisms.

The reasons for inappropriate refractive correction include: (1) biometric or IOL calculation errors; (2) keratometric changes resulting from the corneal incision wound; and (3) IOL rotation or tilting in the capsular bag.[20] In a previous study, 54% of the errors in the predicted refraction after IOL implantation were attributed to errors in axial length measurements.[25] Optical biometry can avoid corneal indentation and measure the axial length along the visual

Table 1
Visual and refractive outcomes of patients undergoing implantation of the T-flex toric intraocular lens.

	Preoperative value	Postoperative value (6 mo after operation)	*p*
CDVA (log MAR)	0.81 ± 0.45	0.09 ± 0.11	<0.001
UDVA (log MAR)	—	0.14 ± 0.13	—
Refractive astigmatism (D)	3.21 ± 1.50	0.77 ± 0.47	<0.001
Keratometric astigmatism (D)	2.25 ± 0.58	2.22 ± 0.73	0.73
Spherical equivalent (D)	4.47 ± 5.43	0.63 ± 0.49	0.007
Refractive sphere (D)	4.21 ± 4.83	0.59 ± 0.57	0.003

Data are presented as mean ± SD.
CDVA = corrected distant visual acuity; UDVA = uncorrected distant visual acuity.

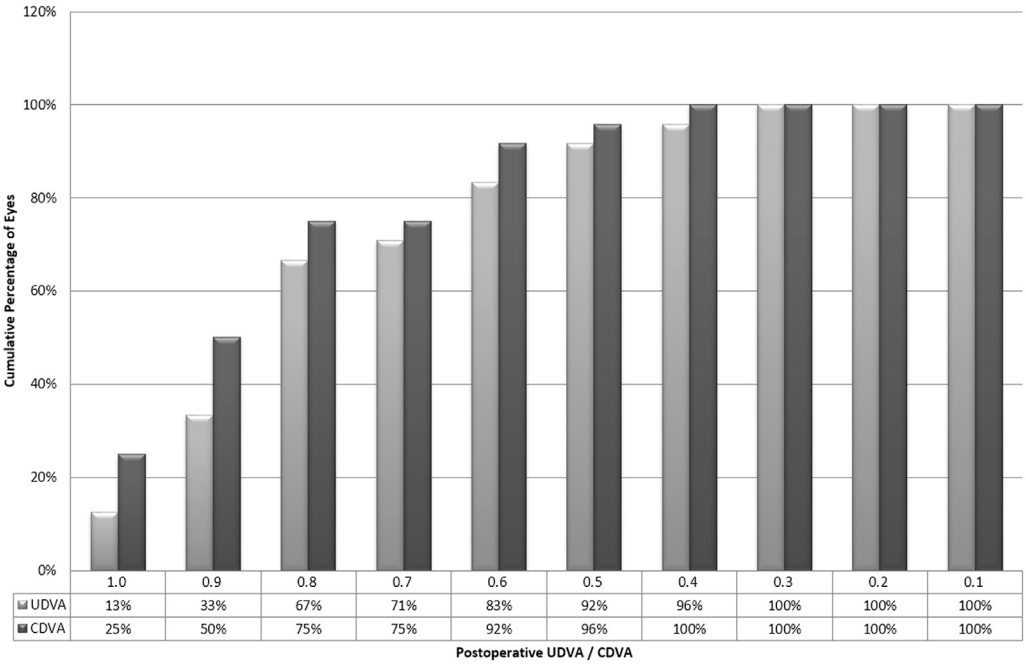

Fig. 1. Cumulative percentage of postoperative uncorrected distant visual acuity (UDVA) and corrected distant visual acuity (CDVA).

axis using the patient's fixation. Optical biometry has improved the refractive results of patients undergoing cataract surgery and has been shown to be more accurate than applanation ultrasound biometry.[25–28] In this study, we used IOLMaster as the measurement tool. The IOLMaster biometric data, including axial length, keratometry, and anterior chamber depth, were input online into the Rayner T-flex IOL Calculator to calculate the IOL spherical and astigmatic power, along with the optimum position of the IOL axis.

Smaller incisions induce less corneal astigmatism after phacoemulsification. Earlier studies have shown that the mean surgically induced astigmatism in a 2.2 mm corneal incision was significantly less than that induced with a 3.0 mm corneal incision after coaxial phacoemulsification.[29,30] In this study, we used a 2.2 mm corneal incision to allow the passage of the coaxial phacoemulsification tips and IOL injectors. No significant changes in corneal astigmatism were found before or after the operation.

Lens stability is important in the effectiveness of the toric IOL. Each degree of off-axis rotation results in a loss of $\leq$3.3% of the lens cylinder power and a 10° IOL rotation reduces the cylinder power by approximately one-third.[30] The cylinder power of the IOL is therefore completely lost if the lens rotates >30°. The IOL rotation usually occurs in the early postoperative period. This can be a result of the incomplete fusion of the anterior and posterior leaves of the capsule, an inadequate capsulorrhexis size, inappropriate IOL design or material, the small size of the IOL, or inadequate clearing of the viscoelastic material.[20] According to the manufacturer, the double-arm haptic design of the T-flex toric IOL is intended to maintain good centering.[20] We removed the viscoelastic material at

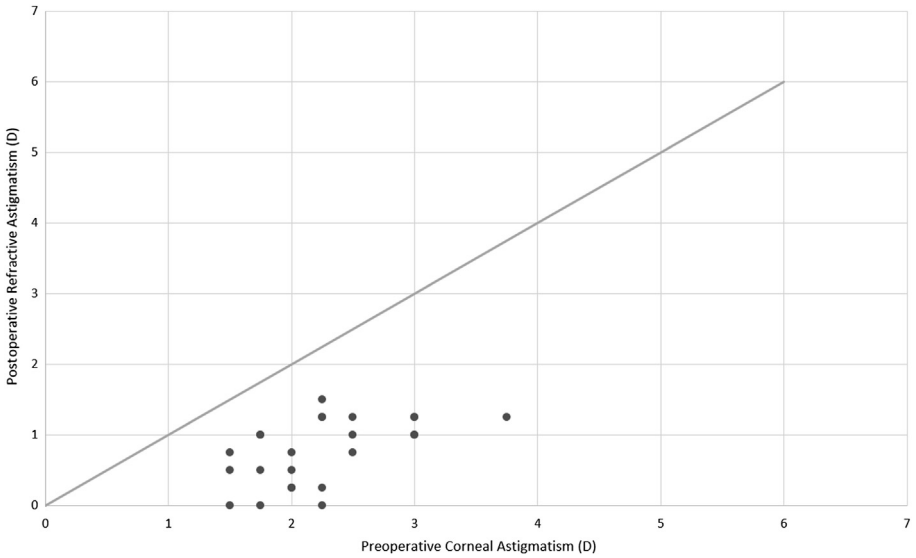

Fig. 2. Correlation of preoperative and postoperative refractive astigmatism.

the front and back sides of the IOL thoroughly and carefully aligned the IOL axis along the corneal reference mark. The mean degree of deviation from the intended axis was <5° in all patients and occurred in the early or late postoperative period in our study.

Entabi et al[20] enrolled 33 eyes with corneal astigmatisms ≥2.0 D. After cataract surgery and T-flex toric IOL implantation, 69.7% of the eyes achieved ≥20/40 UDVA. Four months postoperatively, the mean refractive astigmatism significantly reduced from 3.35 D to 0.95 D. The mean reduction in astigmatism was 2.4 D. The mean CDVA significantly improved from 0.54 logMAR to 0.19 logMAR. The mean difference between the intended and actual final IOL cylinder axis was 3.44°. Alberdi et al[21] reported the outcome of T-flex toric IOL implantation in 27 eyes with corneal astigmatism ≥1.5 D. Three months postoperatively, the mean refractive astigmatism had significantly decreased from 2.81 D to 0.52 D. The mean reduction in astigmatism was 2.18 D. The mean CDVA significantly improved from 0.37 logMAR to 0.07 logMAR. The mean improvement from the preoperative CDVA to the postoperative UDVA was 4.9 lines. Ninety-six percent of their patients achieved a postoperative UDVA ≥20/40. Ninety-two percent of all eyes had an IOL rotation <10°. In our study, the mean refractive astigmatism decreased significantly from 3.21 D to 0.77 D. The mean postoperative reduction in astigmatism was 2.44 D, accounting for 76% of the preoperative cylinder. The mean CDVA significantly improved from 0.81 logMAR to 0.09 logMAR. Ninety-two percent of patients achieved a postoperative UDVA ≥20/40. The IOL rotation was <5° in all of our patients. Therefore the refractive outcome, visual results, and IOL stability in our study were comparable with those in previous T-flex toric IOL studies.

An earlier review article identified 11 relevant studies reporting changes in UDVA after cataract surgery and toric IOL implantation.[31] Four brands of toric IOL were compared, including the Human Optic MicroSil, Rayner T-Flex, AcrySof Toric, and Staar Toric brands. All these previous studies reported improvements in UDVA after the surgical implantation of a toric IOL. The postoperative UDVA was between −0.07 logMAR and 0.39 logMAR. The range of postoperative refractive astigmatism was from 0.28 D to 1.23 D. Our research showed 0.14 logMAR in the mean UDVA and 0.77 D in the mean refractive cylinder after the operation. These clinical results are comparable with previously published work.

In conclusion, T-flex toric IOL implantation is a safe and effective method to correct clinically significant corneal astigmatism during cataract surgery. The limitations of this research include the retrospective study design and relatively small number of patients. Thus a larger prospective study is necessary to confirm the efficacy of the T-flex toric IOL.

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